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Project Summary

Copper Dump Leaching and Management Practices That Minimize the Potential for Environmental Releases

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The full report presents a description of the magnitude and distribution of copper dump leaching, the design and operation of leaching facilities, the potential for environmental impact, and management practices that can be used to minimize environmental releases. The information contained in the report was obtained through searches of published and unpublished literature and through contact with knowledgeable individuals involved in the dump leaching industry. Ten leaching operations were visited to acquire firsthand knowledge and site-specific information.

Seepage from leach dumps and process solution collection systems is the most significant potential mechanism for the release of contaminants. These solutions have low pH and high concentrations of metals and total dissolved solids (TDS). Ground-water impacts have been documented. The application and efficiency of standard waste management practices at dump leach operations are site specific and are limited by the magnitude of these facilities.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Dump leaching refers to percolation leaching of copper from run-of-mine low-grade ores that have been piled on native ground. These dumps typically cover hundreds of acres and contain millions of tons of low-grade ore. The leaching cycle covers a span of many years. The percentage of copper produced by leaching operations has increased and this trend is expected to continue. Currently, there are 18 commercially active copper leaching operations in the United States with a total production capacity of 280,000 metric tons of copper per year. Fourteen of these sites are in Arizona. There are about 23 inactive and abandoned leaching sites.

Sections 8002(l) and (p) of the Resource Conservation and Recovery Act (RCRA) and its amendments require the U.S. Environmental Protection Agency (EPA) to conduct studies on the "adverse effects on human health and the environment of the disposal and utilization of solid wastes from the extraction, beneficiation, and processing of ores and minerals." The EPA submitted a report to Congress on December 31, 1985, that indicated concern with the low pH and the potentially high concentration of metals

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found in leachates and leach material associated with copper dump leaching. The EPA subsequently issued a regulatory determination on July 3, 1986, that expressed continued concern about mining wastes having high acid-generation potential. Also in this determination, the EPA indicated that it would develop a regulatory program for mining wastes under Subtitle D of RCRA and collect additional information on the nature of mining wastes and management practices and the potential for exposure to these wastes. The full report addresses these issues with regard to the development, operation, and closure activities associated with copper dump leaching operations.

General Characteristics

Although the number of active mines in the United States has decreased in recent years, the percentage of primary copper produced by leaching has increased. Low copper prices have resulted in the closing of many mining, milling, and smelting operations. Although many of the leaching operations associated with these sites also have been closed, a significant number are still active because of the relatively low operating costs associated with dump leaching. The result has been an increase in the percentage of copper produced by leaching operations in the United States. Estimates indicate that by 1990 approximately 30 percent of the copper produced in this country will be recovered by some type of leaching process.

The areas in which copper leaching is practiced are similar in general characteristics. Most of the active U.S. copper dump and heap leaching sites are in the Southwest. The climate in these areas ranges from arid to semi-arid. The topography of these areas varies from gently rolling hills to mountainous terrain. Vegetation is sparse. The active leaching operations in Utah and northern and eastern Arizona tend to be located in more mountainous terrain than those in southern Arizona and western New Mexico. The land surrounding many of the active leaching operations consists primarily of sparsely populated and undisturbed vacant land. Some of the active leaching operations, however, are relatively close to residential and urban areas.

Very little surface water is found near active leaching sites in the Southwest. The depth to ground water, which is the principal source of water most of these mines, varies. In the more mountainous environments, however, the amounts of surface-water runoff and ground water are greater because of winter snow accumulation.

Operating Practices

Copper leach dumps typically cover hundreds of hectares, are more than a hundred meters high, and contain millions of metric tons of leach ore. Copper leach piles as small as 8 hectares (Cyprus Johnson) and as large as 850 hectares (Bingham Canyon) were observed during this study. Estimates indicate that more than 5.5 billion metric tons of leach ore now exist in copper leach dumps scattered around the United States and in excess of 40 million metric tons of new material is being added to these dumps annually.

Dump leaching and heap leaching are distinguished by the use of liners. Dump leaching refers to the leaching of low-grade ore that has been deposited directly on the ground. The pregnant leach solution is typically collected in unlined natural drainage basins. In contrast, heap leaching refers to the leaching of ore that has been deposited on specially prepared pads. Dump leaching operations are always constructed in the immediate vicinity of the mine site. Leach sites are selected to minimize haulage costs and to utilize the natural drainage patterns of the native terrain for collection of the pregnant liquor solutions.

Leaching of copper from massive dumps of sulfide ore is accomplished bacterial activity and, often, by the addition of sulfuric acid. Ferric sulfate, the major lixiviant, forms in the presence of oxygen and bacterial activity. The bacteria generate acid in situ, which provides acid for acid-consuming reactions, including oxygen reduction. Frequently, only makeup water is needed in copper dump operations because the oxidation of the sulfide minerals generates sufficient acid to dissolve the copper and maintain an active bacterial population. More effective leaching reagents have been identified, but they are generally much more expensive and their impact on the environment is uncertain.

Copper is recovered from pregnant leach liquors either by cementation or by solvent extraction/electrowinning. These processes remove copper from solution and allow other dissolved substances to accumulate. The recovery process itself may add other substances to the leach solutions. The cementation process uses scrap iron to precipitate copper from the pregnant solution. The iron replaces copper in solution, and this iron-rich solution is subsequently recycled to the top of the leach dump. Upon exposure to the atmosphere, the dissolved iron oxidizes to form insoluble salts, which precipitate on the surface of the dump and restrict the flow of solution. Solvent extraction uses a complexation mechanism whereby copper is chelated; the copper is then stripped from the organic carrier by a strong acid solution. Kerosene is a common carrier used in most solvent extraction operations, and it may appear in small quantities in the raffinate recirculated the dump.

Environmental Impact

Seepage from leach dumps and solution collection systems is the most significant potential mechanism for the release of contamination into the ground water. One of the primary criteria in siting leaching operations is proximity to the mine. In dump leach operations, the ground surface is neither lined nor treated in any manner to reduce seepage. Because the leaching solutions are in direct contact with the earth, some continuous solution loss results. Releases can also result from pipe and dam failures, equipment malfunctions, and overflows due to severe storm events.

The solutions generated in copper dump and heap leaching operations usually have a lower pH and higher concentrations of metals and total dissolved solids than the natural waters surrounding the site. Leach ores contain pyrites and other naturally occurring metal sulfides that oxidize to generate a low-pH solution when exposed to air and microbial activity. The solvent extraction process also reduces the pH of the solution by ion exchange before it is distributed on the leach dump. Generally, acidic solutions increase the solubility and bioavailability of heavy metals contained in the leach material and rock surrounding the dump.

The water quality around several active copper dump leaching operations has been affected by leachates that have seeped into the ground water. The available ground-water monitoring data indicate that some degradation of the ground water has occurred around several copper dump leaching operations. Some seepage of leachates into the ground beneath copper leach dumps is inevitable. The amount of seepage and its impact depend on site-specific factors.

Management Practices

Most active copper leaching operations have implemented a system of management practices that includes one or more mitigative measures designed to minimize solution losses. Historically, such management practices were implemented solely for economic reasons (to improve copper recoveries). As the potential for ground-water contamination problems associated with leaching became apparent, these practices were implemented for environmental reasons as well. The measures used at a particular site depend on various site-specific factors, the most significant of which are the geology, hydrogeology, topography, and meteorology of the site. The land use and population density of the area surrounding the operation are also considered, as is the cost of constructing and/or installing each potential mitigative measure.

The application and efficiency of standard waste management practices at copper leaching operations are frequently limited by the size of the dump and environmental characteristics of the site. Copper leaching operations are massive; thus, management practices required for adequate control of potential ground-water contamination from leaching operations also must be on a very large scale. The geologic and hydrogeologic evaluation required to design and implement an effective surface-water and ground-water control system is complex, and the required control systems must cover several hundred hectares. The environment of the site may necessitate a system to divert surface water resulting from the torrential rains periodically experienced in the region, but annual precipitation may not be adequate to sustain revegetation efforts. The size of the leaching operation and its surrounding environment often combine to make both lining of new facilities and capping economically impractical.

The cost of implementing and maintaining an effective system of management practices to minimize solution loss and reduce potential ground-water contamination depends on site-specific factors. Traditional management practices tend to be very expensive to implement at copper leaching operations because of the size of the operations and the natural characteristic of the site. Nevertheless, several of these practices have been implemented economically at or around one or more leaching operation. Proper planning and design procedures are required to select the most appropriate management practices and to minimize costs.

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The complete report, entitled "Copper Dump Leaching and Management Practices That Minimize the Potential for Environmental Releases" (Order No. PB 88 155 114/AS; Cost: $19.95, subject to change) will be available only from:
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